DULL

Description of a design of a 1000-ton fueling lighter

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DESCRIPTION OF A DESIGN OF A 1000-TON FUELING LIGHTER

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED Description of a Design of a 1,000-ton Fueling Lighter

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D E S I G N O F A 1,000 T O N
F U E L I N G L I G H T E R

General Description

The coaling of vessels in harbors is getting to be a very serious problem, and various attempts have been made to effect a saving of both time and money. It is very difficult to handle large freighters in a crowded harbor, and it is necessary to employ high salaried pilots, and even then accidents are not infrequent. The phase of the matter which troubles the managers of transportation companies, is the expense of coaling and the loss of time incident to coaling.

The writer has made a study of this problem, and co-operating with a shipbuilder for the hull, has secured the contract for building and equipping with unloading machinery, a fueling lighter to suit the special needs of a transportation company operating in the harbor of Buffalo. The freighters to be fueled handle iron ore and in some cases are six hundred feet long and have a beam of sixty feet. It can readily be seen that to handle several such vessels at docks, and coal them rapidly, is very difficult.

In going into the design of a fueling lighter, it was found necessary to design a boat which would not draw much water, and which would permit of rapid handling but not necessarily a boat designed for rough sea. A

flat bottom boat design was selected, with twin screws and twin rudders. This type of boat will turn around in almost its own length.

The capacity of boat selected is 1,000 tons. The boat is 166 feet long and thirty-six foot beam, and is propelled by two vertical marine type reversing engines, with 18" x 20" cylinders. These engines at 150-pound steam pressure, develop about 200 h. p. each. They are direct connected to 84" diameter propellers, which gives the vessel a speed of about 10 miles per hour.

The cargo compartment of the boat is divided into twenty-two hoppers, eighteen of which have a capacity of fifty tons, and four have a capacity of twenty-five tons of coal. The hopper is contracted down to a five-foot opening at bottom and provided with reciprocating feeding gates which deliver coal to the pan conveyors running longitudinally in the center of the bottom of the boat.

The original conception of the proposition contemplated the use of feeding conveyors, dropping the coal directly into them and simplifying the machinery by omitting the feeding gates, which added about two thousand, five hundred dollars to the cost of the machinery. The plan was abandoned because it was found that this arrangement raised the cargo so high in the boat that it made the boat "too touchy," as the shipbuilder termed it.

Figure #1 shows the general arrangement of the lighter and the arrangement of the cargo compartments.

The compartments were made fifty tons capacity because fifty tons is about a car load. It was found necessary to divide the two forward compartments by center bulkheads, making them twenty-five tons compartments, because it was necessary at times to give a boat only twenty five tons, and this was the only means of determining the amount. The coal is sold by measure, and tests were made to find an average space a ton of coal would occupy, and this was found to be forty-two cubic feet.

The pilot house and signal mast are located forward, and the power plant aft, as is usual in freighters. Steam power winches are located both forward and aft, and it is a matter of a few minutes to secure the lighter to the freighter to be coaled. The unloading device is located in the center of the boat, or nearly so to permit coaling, no matter which direction the boats are in relation to each other. That is, whether the sterns are together or on opposite ends.

The structure for the unloading machinery consists of a tower of very rigid and heavy construction, which encases the elevator and supports a swinging boom pivoted at the lower end by a turntable, and suspended by multiple blocks at the other end. The tower is extended above the elevator and houses in, to form an operator's room, from which all parts of the equipment can be observed, and any part or all, of conveying or hoisting machinery shut down instantly. Controllers for all the

motors are located in this tower, as well as operating devices for the reciprocating gates which feed the conveyors. The control of the hoisting and swinging apparatus is accomplished from this tower. It is readily seen that the whole system of unloading is concentrated under the control of one man in the tower, while the navigation is under the direction and control of another man in the pilot house.

CONVEYING MACHINERY

The pan conveyors under the hoppers of the boat designed for this particular service, consist of two extra deep pan conveyors, forty-two inches wide with beaded edges and offset ends. They are mounted on two strands of 3" x 3/8" steel bar link bushed chain, having a pitch of 18." The pitch of the pans is eighteen inches also, and when they are bolted onto the chain links, form a continuous corrugated apron or steel belt for carrying the coal. The ends of the pans are extended upward and lap over each other, forming continuous sides to prevent material from spilling over into the chains. Skirt boards are extended upward still further over the pan ends to make possible the loading of the conveyors to an extra depth for emergency cases, when it is necessary to coal a vessel at an extra high rate of speed.

The speed of these pan conveyors is variable, and has a range from fifty feet to one hundred feet per minute. It was necessary to make this lower conveyor system in two units, because the elevating apparatus is

located in the center of the boat approximately. It was decided that this was an advantage because if one was damaged in operation, the boat could still be operated with the other machine at a reduced capacity.

Cross axles were provided for each pan instead of at intervals, as they are usually designed, to prevent the chains from cramping and not operating properly.

The chains were designed for a working stress of six thousand pounds for each strand, and are fitted with steel bushings set in oblong holes in the links to prevent motion between bushing and links, and the consequent wear to them. The axles run through the bushings and all motion is between the axles and the bushings when the chain articulates. The chain rollers run on the bushings and it will be noted that the bushing (which is a renewable part) is the member which suffers the severest wear. When these bushings are renewed and the rollers rebushed, the chain is practically as good as new. A very important feature of this chain design is, that due to the wide bearing surface, the pitch of the chain is maintained for a very long time, and as there is no motion between the chain links and the bushings when new bushings are inserted, the original pitch is maintained. This is a very important point in steel chain designs, for when the pitch of the chain becomes smaller, the chain will ride on the sprocket teeth and give considerable trouble. It can readily be seen that as the pockets in the sprockets wear deeper,

the chordal distance (which is the pitch) becomes very much less.

The sprockets for these conveyors were designed especially for this contract. They are 42" in diameter, having a solid web center stiffened with seven ribs, and an outer flange. Bolted to the "Y" shaped pockets in the outer flanges, are seven renewable steel roller pockets with friction board shims beneath to permit of easy adjustment of pitch, as well as an adjustment later after the sprockets have become worn, in order to bring the pockets for the chain rollers to accurate pitch again. This construction makes possible the use of either cast iron or cast steel sprocket centers. There is quite a variation in the center diameters when made of cast iron, and when made of cast steel from the same pattern, but this variation is adjusted by widening the shims under the chain roller pockets which correspond to sprocket teeth. This sprocket diameter as designed is used throughout on all the conveying machinery.

Lubrication of the chain joints is accomplished by means of #2 grease cups of special design on the end of the chain axles. The axles are drilled along their axis, and cross drilled, to lubricate both the bushings and the rollers. This is a new departure, both in chain lubrication and sprocket design, and we expect some very interesting results.

The driving machinery was designed very carefully

and corsisted of 3-15/16" diameter head shafts and 48" diameter, 2" pitch cast steel spur gears with clamp hubs. The countershafts are 2-15/16" diameter with 8-1/4" cast steel pinions, 2" pitch, engaging the 48" spur gears on the head shafts. Cast steel gears 36" diameter with cut teeth, engage cast steel spur pinions 6-3/4" diameter on the back gear of the motor, which completes the train of gears for the drive. The whole drive is mounted on steel framework of a very substantial design, which is very necessary for the successful operation of this class of machinery.

The foot shafts for these pan conveyors have special spring type takeups. These takeups for increasing the tension between the head shaft and the foot shaft usually have a rigid screw adjustment, but in the design for this machinery a new design is used, which has a large helical spring between the nut on the screw and the foot shaft bearings, which makes a more flexible adjustment. As long pitch sprocket wheels are really polygons, and unless the distance between the head and foot sprocket is a multiple of a certain distance to make them revolve in unison, there is a variation between the centers of the head and foot shafts, and if there is a rigid connection for both shafts, the conveyor will not operate very successfully.

The chain rollers run on steel rails weighing 20 pounds to the yard. The rails are supported on special cast iron chairs designed to suit this condition, and are

fitted with steel clamping and adjusting clips for securing the rails.

Figure #2 is a photograph taken during the process of manufacture of this type of pan conveyor.

ELEVATOR

The raising of the coal in the tower is accomplished by a 48" x 30" gravity discharge elevator.

The buckets are 48" long, 30" wide and 26" deep, and weigh approximately 315 pounds each. They are made 1/4" steel reinforced on the two edges and fitted with 1/4" steel flanged ends. They are spaced every 36" between two strands of 3-1/2 x 1/2" steel bushed chain of the same design as the chains for the 42" pan conveyors, except heavier and stronger. These chains have 1-1/4" steel pins and 1-3/4" diameter steel bushings. The working stress of these chains is 10,000 pounds for each strand. The maximum total load is about 14,000 pounds. Figures 3, 4, 5 and 6 give a very good idea of the bucket and chain design for this elevator.

An unusual design of this elevator, which will undoubtedly startle builders of conveying machinery, is that the bottom run of the elevator has no sprocket wheels, but follows a curved track describing a semi-circle at the foot in the boot. We believe that this feature will decrease the breakage of coal considerable, as it will not come in contact with the corner sprocket idlers. The driving and tightening devices are at the top of the tower.

The head shaft is 4-15/16" diameter, driven by a 64" diameter, 2" pitch cast steel spur gear, with clamp hub.

The countershaft is 3-7/16" diameter with 12-3/4" cast steel spur pinion engaging the 64" spur gear on the head shaft. The countershaft is driven by a 32-1/2" cast steel spur gear with clamp hub and cut teeth. The elevator is driven by a 40 h. p. back geared variable speed motor, with 10" pinion engaging the 32-1/2" spur gear on the countershaft.

The corner shaft is 3-15/16" diameter and has the spring type takeup of the same design as the pan conveyors, but heavier and more powerful.

To give an idea of the size of this elevator, the moving parts weigh about 12 tons. This is quite a load, considering that the lift is only 33 feet. The speed of this machine varies from fifty feet per minute to one hundres and twenty feet per minute. The bottom of the elevator is provided with a steel boot with a curved bottom having approximately the same radius as the outer lip of the bucket.

CONVEYOR ON BOOM

The conveyor on the boom is an extra deep open top carrier, 42" wide, 18" pitch and 19-1/2" deep. The carrier buckets are made of 3/16" steel because the weight of heavier machines complicated the handling of the boom. This carrier is very different from any ever manufactured. It is supported by the cross axles and has no connection to

the chain links. The connections to the cross shafts resemble a huge hinge made in five sections, with the axle as the pin for the hinge. It is impossible for very much material to fall through this joint, no matter what position the buckets take. This construction permits the removal of the buckets in case of damage, without disturbing the chain. This machine will operate at an inclination and it would be difficult to disconnect the chain and make repairs quickly.

The driving machinery is very similar to the elevator driving machinery, and consists of a 4-15/16" head shaft, and 64" cast steel spur gear, 2" pitch, engaging a 12-3/4" diameter pinion, 2" pitch on the countershaft. The countershaft is 5-7/16" diameter and has a 32-1/2" cast spur gear engaging a 9-1/2" spur pinion on the back gear of the motor. The foot shaft is 3-7/16" diameter and is provided with the spring type takeups in the same manner as the other conveyors. It is the same design as the 42" pan conveyors in the hold of the boat.

HOISTING APPARATUS

The main hoist for raising and lowering the boom consists of a 24" diameter drum, with double flanges, geared direct to a spur pinion fitted with a mechanical brake, or lowering device. The pinion is bored and threaded with square threads and mounted on a pinion shaft with corresponding square threads cut out of the solid metal. A flange is cast on one side of the pinion, and the direction

of motion of the pinion, screws the flange against a second flange, which is keyed securely to the shaft. Between the two flanges is a friction disc with ratchet teeth engaging a fixed pawl. The ratchet prevents the hoist from rotating backwards, unless the motor is reversed. When the motor is reversed the discs are separated by the screw, and the boom will be lowered just as rapidly as the motor revolves, for the weight of the boom screws the pinion disc against the friction ratchet at the same speed that the reversed motion of the motor relieves it. This mechanical brake is not a new principle, but never has been applied to this kind of work to our knowledge.

The wire rope leading from the drum makes five turns about heavy sheave blocks, making a total of ten 3/4" diameter plow steel wire ropes for supporting the boom. The hoist is located on deck in the elevator tower.

BOOM SWINGING DRUM

The swinging drum is a 24" diameter drum, 12" face, mounted on a vertical shaft. The swinging ropes pass around a 180" diameter bull wheel on the turntable, and lead back to the swinging drum.

The countershaft is connected to the drum shaft by bevel gears made of cast steel. The flanges of the drum are extended and machined for a powerful strap brake to hold the drum in any position.

DELIVERING SPOUT

The delivery spout at the end of the boom is

pivoted on ore edge and swings through an angle of 90 degrees. It is moved by wire cables winding on small drums, rotated by a reversing motor on the end of the boom.

This spout is expected to do all the trimming necessary, and will be controlled from the tower.

SAFETY APPLIANCES

It has been the aim throughout the design, to make all the machinery very substantial and "fool proof" if possible. All gears and sprocket wheels are made of cast steel and all parts are made extra heavy to prevent accidents due to breaking of parts. The gears have guards and hand rails where necessary, and all the hoisting motors have solenoid brakes so arranged that when the current is off of the motor, it is on the solenoid. The elevator and boom conveyor have safety pawls which engage the teeth of the gears in case the power is thrown off suddenly, due to a cut-out in the circuit. These ratchets will not permit these machines to rotate backwards.

METHOD OF CONTROL

The control is arranged to stop all machinery in case one circuit is cut out, because if one is not carrying coal, the others must not dump into it and cause a jam.

All the motors are controlled from the operator's tower, and street car type controllers are used with reverse switches. In case of a minor jam of coal, the motors are reversed and loosen the jam readily. The conveyors can be

operated similarly to a street car. They can be started at a moderate rate of speed and by means of the controllers, increased to full speed. They can also be reversed. We are arranging, also, to operate the feeding gates from the operator's tower.

ELECTRICAL EQUIPMENT

The conveying system requires six, 15 h. p. motors and two, 40 h. p. motors. They are furnished current at 220 volts by a 100 K. W. generator, direct connected to a 150 h. p. high speed engine.

The motors are mill type motors of the multipole type, compound wound, with field control for the conveyor motors, and series wound for the hoisting motors. Some of these motors were made a little larger than necessary, but our object was to keep the different kinds down to as small a number as possible, and then keep spare motors on hand for repairs. These motors are very sturdy and suitable for this service, and have cast steel frames.

The switch board for the generator set is located near the generator in the power plant, and the distributing panels for the motors are located in the tower room.

The boat is expected to handle about one-half of a million tons of coal each season.

GUARANTEE

The conveying system is to have a guaranteed capacity of five hundred tons per hour, without overload, and the equipment will, without question, fulfill this condition.

The contract price for the lighter, complete, is nearly one hundred thousand dollars, and the purchaser expects to build two more if this one is a success. This is the first fueling lighter of this type, and will undoubtedly attract considerable attention. There is a great need of fueling lighters in every important harbor in the world, and the writer expects to see several in operation within the next five years.

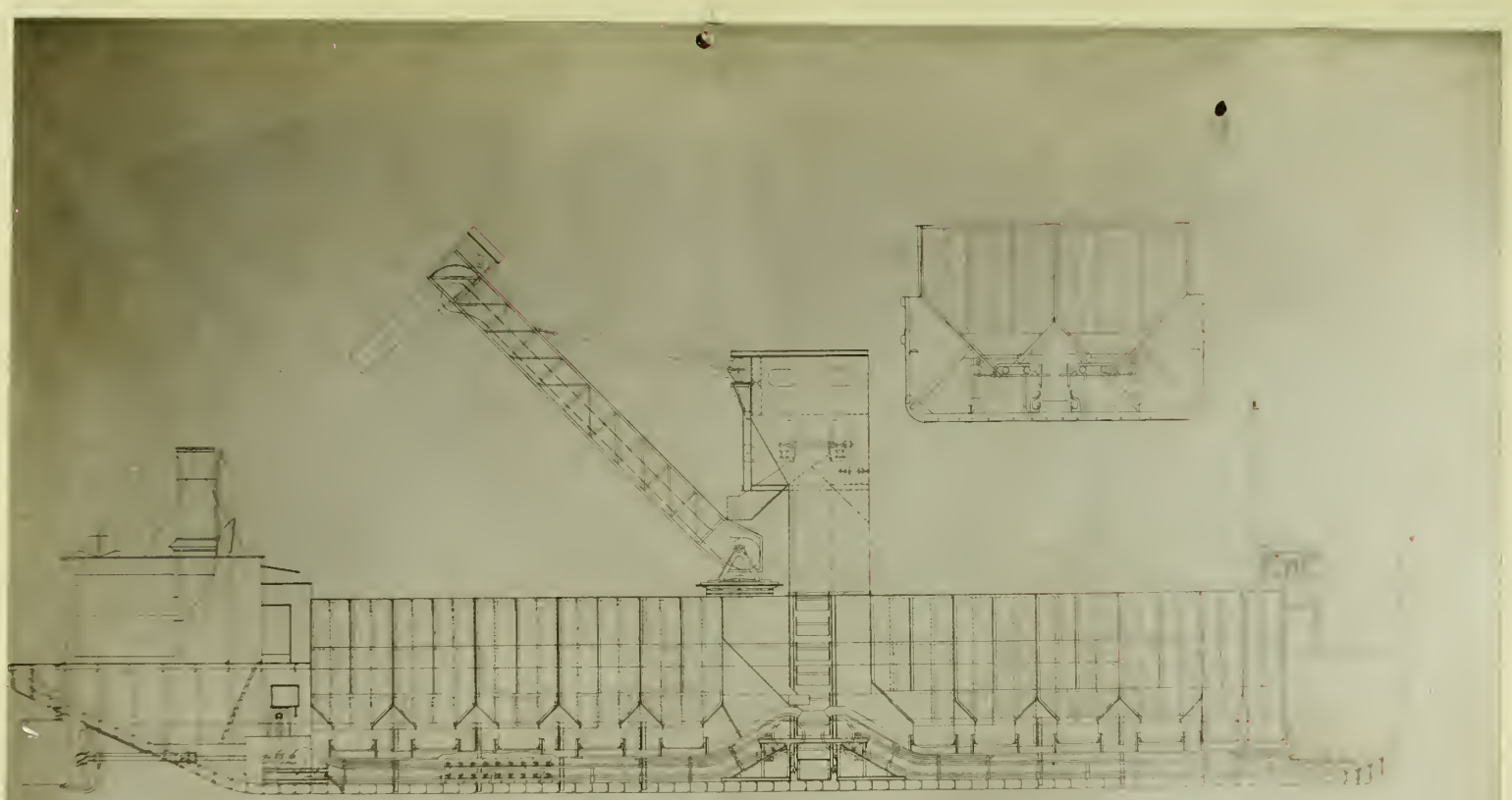

FIG. 1.